Method and apparatus for pretreating paper pulp

The present invention relates to a method of and apparatus for pretreating paper pulp. The method and apparatus according to the invention are especially preferably applicable to be used in paper machine approach systems in order to optimize the operation of the so-called short circulation.

Almost all prior art paper machine approach systems feeding paper pulp to the paper machine, which are well described in, e.g., US patent publication 4,219,340, comprise the following components: a white water tank, a centrifugal cleaning plant with feed pumps and pumps between various stages, a gas separation tank with vacuum providing means, a fan pump, a head box screen, a paper machine head box, and white water trays. Said components are placed in connection with the paper machine and arranged to operate as follows: The fiber material used for paper making and the fillers which are diluted with the so-called white water obtained from the wire section of the paper machine, are dosed from the machine chest into the white water tank usually located at the bottom level of the mill. By means of a feed pump also located at the bottom level of the mill, the fiber suspension is pumped from the white water tank usually at the machine level of the mill, i.e. the location level of the paper machine, or, as in said patent, to a first cleaning stage of a centrifugal cleaning plant located above it. The centrifugal cleaning plant usually comprises several (most commonly 4 – 6) stages, each typically having a feed pump of its own. By means of pressure created by said feed pump, the fiber suspension accepted in the first cleaning stage of the centrifugal cleaning plant is further conveyed to a gas-separation tank typically located at a level above the machine level. In practice that means about 10 – 12 meters above the surface of the white water tank. In the gas-separation tank the fiber suspension is subjected to the effect of vacuum created by vacuum apparatus, which most commonly are liquid ring pumps, whereby both part of the gas dissolved in the suspension and the gas in the form of

small bubbles in the suspension rises above the surface of the liquid in the tank and is discharged from the tank through the vacuum apparatus. From the gas-separation tank the fiber suspension, wherefrom gas has been removed as thoroughly as possible, flows to a fan pump located at the bottom level of the mill, which feed pump further pumps the fiber suspension to a head box screen (not shown in said US-patent) also located at the bottom level of the mill, whereafter the fiber suspension flows to the machine level into the head box of the paper machine.

One problem in the paper machine approach system of prior art is its huge volume mostly due to the volume of the gas separation tank and the centrifugal cleaning plant as well as the long and large-sized piping. Volume in itself is not a major problem, except for space utilization and the point that it involves relatively big investments, but long delays due to great volumes essentially restrain the grade change and lead to great amounts of broke in connection with the grade change. In connection with the grade change, broke is formed of all the pulp being used to produce the final product before the relative amount of all components of the fiber suspension have been equalized throughout the approach system to correspond to the content of the desired final product.

Said problem has already been dealt with in FI patent 89728, according to which different types of white waters are collected from the wire section of the paper machine and guided directly to the short circulation of the paper machine without employing any actual white water tank. In said publication, under each white water tray there is a pump for delivering the white water to a suitable location. The publication describes the white water channels to be very flat, i.e. of small volume, so that the delays remain as short as possible. In the solution according to said publication, arranged at the side of the wire section there is a small pumping container and means providing pumping operation, from which the white water is further delivered to the process. The deaeration reached by means of this

apparatus is not efficient enough to provide undisturbed operation of the paper machine, though.

In addition to problems related to space utilization and great liquid volume, it may be noticed that the centrifugal cleaning plant creates other problems, too. The traditional location of the centrifugal cleaning plant in the paper machine approach system has been explained on the grounds that the location is chosen to ensure that the fiber suspension just prior to the head box of the paper machine is free of particles unsuitable for paper making, such as sand, bark specks, slivers and even over-sized filler pieces, which may all be called as, e.g., impurities or impurity particles. During the tests we have made we have noticed, however, that especially in the case of paper machines producing filler-containing grades, a major part of the fraction rejected by said centrifugal cleaning plant, that is fraction removed from the flow going to the paper machine head box, is as such suitable for papermaking. One reason for this is that the cyclones of the centrifugal cleaning plant are dimensioned to prevent any unsuitable material from passing into the head box, and, on the other hand, the centrifugal cleaners may be planned to operate in an optimal way with one material only or a few very similar materials. Taking into account e.g. the very different densities of various components, such as e.g. fibers and mineral-based fillers, it is easy to believe that in that kind of application the centrifugal cleaning plant can not perform optimal function with regard to any component, but the basic goal of the centrifugal cleaning plant has to be to keep the ratios of the components in the fiber suspension essentially unchanged during the cleaning and to prevent any particle unsuitable for papermaking from entering the head box of the paper machine. In fact, the same problem is dealt with in FI patents 93753 and 97736, although accepting the presence of reject from the centrifugal cleaning plant.

One preferable solution to the problem mentioned above is said to be separate treatment of every component of paper pulp: fresh fiber

suspension, pulp broke, recycled fibers, fillers, etc in their own sections prior to mixing the components together. In that case, in each application it is possible to choose the most suitable cleaning method and apparatus for each component. The result is that only clean fractions are introduced to the short circulation of the paper machine and the centrifugal cleaning plant is not needed at all. In addition to that, cleaning every component with an apparatus dimensioned and adapted for that special purpose is essentially more efficient and economical in view of energy consumption and the selection of appropriate devices for performing the cleaning compared with the centrifugal cleaning plant of prior art.

There are still some additional problems caused by the centrifugal cleaning plant. Due to great liquid volume and complex flow piping, the centrifugal cleaning plant tends to, if not directly create fluctuation in paper pulp flow and pulp pressure, at least maintain and possibly strengthen these fluctuations. Further, a complex centrifugal cleaning plant comprising several (most commonly 4 – 6) stages and a large amount of relatively small-sized flow units creates a major flow resistance, the compensation of which using several large-sized centrifugal pumps is very power-consuming. Usually there is a separate feed pump for each cleaning stage of the centrifugal cleaning plant, in which case the total power requirement of all the pumps of the short circulation of the paper machine in an average-sized mill is in the order of 2 MW.

Another factor having an effect on the power consumption of especially pumping is the location of the short circulation components of the mill in relation to each other. The first disadvantage is noticed to be the location of the gas separation tank usually being placed at a level above the machine level. If it would be possible to bring the gas separation tank to the machine level, it would eliminate the need to pump the fiber suspension with the feed pump higher than the machine level. A precondition for this is, though, that the gas separation tank has to be

constructed either to function without overflow, because the functioning of overflow requires a relatively high free fall, in practice from above the machine level to the level under the machine level, or to comprise a pump arranged in connection with the overflow to create the pressure difference ensuring the functioning of the overflow. In other words, the surface level of the gas separation tank (to be more exact, the inlet pressure of the fan pump) could not be determined by means of overflow, when applying the first alternative, but some substitutive method should be found. Because the basic goal of the regulation of the surface level of the gas separation tank is, as already mentioned before, to maintain the inlet pressure of the fan pump constant, it is in fact more economical to use a regulation system taking into account, in addition to the changes in the surface level, also the fluctuations in paper pulp density, which may sometimes be remarkable. As a result, this kind of change will be accompanied by improvement in paper quality and stabilization of the manufacturing process. Thus, the result is a solution that is more economical in view of energy consumption in pumping and, at the same time, has a distinctly positive effect on paper quality and process runnability.

A further factor having an effect on the energy consumption of pumping in the paper machine approach system is the height of the white water tank. The white water tanks, i.e. tanks wherein the so-called white waters from the paper machine are collected, have traditionally been almost ten meters high, relatively large containers located at the bottom level of the paper mill, and the surface level of these tanks has fluctuated a lot. One reason for the differences in the surface level is e.g. the location of the white water tank in connection with the machine. In the case of a so-called fourdrinier machine, the white water tank, in that case also referred to as the wire pit, has been located under the wire section, whereby even constructional reasons have caused the surface level of the white water tank to be relatively low. The surface level of a white water tank arranged at the side of the wire section or the like (a so-called off-machine silo), in turn, is not

always as high as it might in practice be. The big size of the white water tank has been justified on the basis that the presence of a big buffer tank has been regarded as a positive factor stabilizing the process. This has also caused some increase in energy consumption, because at first the feed pump has had to compensate the sometimes low surface level of the white water tank, and extra delays in the process due to the big volume of the white water tank.

Said location of the white water tank at the bottom level of the mill, that is, under the machine level, may be avoided in the approach system according to the invention. The solutions according to the invention make it possible to arrange the white water tank at the machine level, whereby also the gas separation tank feed pump located at the side of the white water tank is placed at the machine level.

When solving said problems e.g. in the way described before, it is possible to develop the paper machine approach system further by employing as gas separation tank feed pump a propeller pump with a substantially smaller power requirement and with a capacity to head ratio essentially better compared to a centrifugal pump. In this case, the stock, either all or at least the main part of it, is fed into the gas separation tank by means of said propeller pump. As to practical characteristics, the propeller pump is better suited for the purpose than the centrifugal pump, but earlier it has not been possible to use it in said application, because the propeller pump has not met the head requirements of prior art processes. Compared to the power requirement of about 2 MW of said prior art apparatus, the employment of one propeller pump results in a power consumption of about 200 kW, i.e. it is possible to save about 90 % of the power needed.

It is possible to develop the paper machine approach system still further according to a preferred embodiment of the invention by totally abandoning said gas separation tank feed pump from the approach

system. In some suitable conditions this may be done simply by bringing the gas separation tank down to the machine level, whereby the pressure difference needed to transfer the fiber suspension, totally or at least the main part of it, from the white water tank to the gas separation tank is so small that it may be created by means of the vacuum apparatus i.e. vacuum pump/s of the gas separation tank. The arrangement according to this embodiment may, if necessary, be provided with a valve for controlling the flow from the white water tank to the gas separation tank.

Some of the advantages of utilizing the method according to the invention are, e.g.:

- overall decrease of reject in papermaking due to more accurate screening,
- more stable operation of the paper machine short circulation,
- smaller flow resistances in the paper machine short circulation,
- space saving in the paper machine short circulation,
- saving of energy needed for pumping,
- shorter delays,
- quick grade change,
- a cleaner process, no microbe growth,
- simple construction – economical investment.

The characteristic features of the method and apparatus according to the invention are described in the appended patent claims.

In the following, the method and apparatus according to the invention are described in more detail with reference to the appended figures, of which

Fig. 1 illustrates mainly a prior art solution according to US-patent 4,219,340,

Fig. 2 illustrates a solution according to a preferred embodiment of the invention, and

Fig. 3 illustrates a solution according to a second preferred embodiment of the invention.

The prior art approach system illustrated in Fig. 1 comprises a white water tank 10, a feed pump 12, a centrifugal cleaning plant 14 (with several stages not shown), a gas separation tank 16 with its vacuum apparatus 17, a fan pump 18, a head box screen 20, a head box 22 of the paper machine and white water collection channels (not shown). Said components are placed in connection with the paper machine 24 and arranged to operate as follows. Fiber material used in paper making, which may comprise fresh pulp, secondary pulp and/or broke, and fillers which are diluted with the so-called white water obtained from the paper machine, primarily from its wire section, are introduced into the white water tank 10 into which the white waters are collected and which is usually located at the bottom level of the mill in prior art arrangements, to produce paper pulp. By means of a feed pump 12, also located at the bottom level of the mill, said paper pulp is pumped from the white water tank 10 to the centrifugal cleaning plant 14 usually located at the machine level K of the mill (the location level of the paper machine 24), which cleaning plant most usually comprises 4 – 6 stages. Stock accepted by the first stage of the centrifugal cleaning plant 14 proceeds further under pressure created by the feed pump 12 (and with the contributory effect of the vacuum of the gas separation tank) into the gas separation tank 16 located at a level T above the machine level. The gas separation tank 16 typically comprises an overflow to keep the surface level of stock in the tank constant. At the overflow the stock discharged from the tank flows down under the machine level into the white water tank 10 located at the bottom level of the mill. From the gas separation tank 16 the essentially gas-free paper pulp, i.e. pulp from which gas has been removed as thoroughly as possible by means of the vacuum apparatus 17, flows into the fan pump 18 located at the bottom level of the mill, which fan pump pumps the paper pulp further to the head box screen 20 also located at the bottom level of the mill,

wherefrom the accepted paper pulp flows to the machine level K into the head box 22 of the paper machine 24.

Figure 2 illustrates a solution according to a preferred embodiment of the invention in connection with a conventional white water tank 10 of prior art. In the solution according to the figure, three pipelines 40, 42 and 44 are connected with the white water tank 10, each pipeline bringing different fiber pulp into the white water tank. Each pipeline 40 – 44 is connected to its own centrifugal cleaning arrangement 46, 48 and 50 respectively. However, it has to be stated that centrifugal cleaning is by no means the only screening possibility, as pressure screens of new type, preferably provided with slot drums, are very well suitable for the final screening of various pulp fractions. Further, one has to notice that it is also possible to connect all said pipelines together, whereby various sorts of pulp are mixed together prior to the white water tank e.g. in a special mixing tank, wherefrom the stock is taken into a so-called machine chest utilized as a buffer tank. Naturally, this kind of mixing needs appropriate dosing which is not described in this text more precisely as it is considered to be known to any person normally skilled in the art. In this embodiment of the invention, each centrifugal cleaning arrangement 46 - 50 is considered to treat its own sort of pulp e.g. so that arrangement 46 treats the pulp broke from the broke pulper of the paper machine, arrangement 48 recycled fiber pulp and arrangement 50 fresh fiber pulp. The figure further illustrates a pump in connection with each centrifugal cleaning arrangement, with which pumps the different pulps are introduced through the cleaner/s into the white water tank 10. Said pumps may, though, be located in the process remarkably further from the cleaner/s. It is even possible to place various treatment apparatus between the pump and the cleaner/s. With this arrangement, each sort of pulp may be treated as optimally as possible, in other words so that each cleaner may be chosen and run according to optimal screening of the sort of pulp in question. After the cleaners illustrated in the figure, the process may comprise various intermediate

tanks, pumpings or other apparatus needed for treatment of each pulp fraction. Further, the embodiment of the figure illustrates a filler treatment arrangement comprising a mixing/dispersing tank 56, a filler slurry feed pump 58 and a centrifugal cleaning arrangement 54 performing the screening of the filler and a pipeline 52 feeding the screened filler material to between the white water tank 10 and the feed pump 120. This arrangement ensures that only really too big-sized filler particles are removed from the filler material flow and either totally removed from the system or e.g. returned back to the dispersing stage. Thus, this solution prevents the rejecting of fairly big filler particles which are still clearly thinner than the paper, which rejecting would be normal in case of a conventional prior art centrifugal cleaning plant. As feed pump 120, a propeller pump is employed which creates a head that is sufficient at least when e.g. there is no centrifugal cleaning plant creating flow resistance between the pump 120 and the gas separation tank 16. And, as already stated, in some cases the feed pump may be replaced with the vacuum apparatus of the gas separation tank, which vacuum apparatus creates the pressure difference needed for transferring the paper pulp.

Figure 3 illustrates a solution according to a second preferred embodiment of the invention. It relates to a new kind of white water tank 100 located essentially (the main part of the white water tank is above the surface of the machine level and the water level is clearly above the surface of the machine level) at the machine level of the paper mill, into which tank the fiber fractions are brought via pipelines 40 – 44 and which has a surface level at the level S_{100}. The figure illustrates in broken lines a prior art white water tank 10 located at the bottom level of the mill and having a surface level at level S_{10}, and a feed pump 12. In some cases, the height difference between the surface levels of S_{100} and S_{10} is several meters, especially in cases where the wire pit is located under the wire section of the paper machine, whereby the difference in height may be calculated directly in extra consumption of pumping energy in an arrangement

according to prior art. In addition to that, a large-sized white water tank creates in the operation of the process a delay of its own. In the solution according to the figure, the height difference dh between the surface levels of the white water tank 100 and the gas separation tank 16 is less than 9 meters, preferably less than 6 meters, suitably 2 – 4 meters, whereby the head requirement of the pump 120 is low enough to fully enable the use of a propeller pump.

It has to be noticed from the above, that although the invention has been described in connection with the paper machine short circulation without a centrifugal cleaning plant, this is only one special embodiment of the method according to the invention. In other words, the method and apparatus according to the invention are applicable also in a short circulation where the centrifugal cleaning plant is located in the traditional position. In that kind of embodiment only some advantages are lost, which would be achievable when applying an embodiment fully in accordance with the invention. Nevertheless, the employment of a propeller pump according to the invention brings such remarkable advantages in all applications that its utilization is always justified.

As noticed from the above, a new method of pretreating paper pulp fed to the paper machine has been developed, which method eliminates many drawbacks and disadvantages of prior art and solves problems that have been disturbing the use of prior art approach systems. From the above it has to be noticed, though, that the individual novel features described in different embodiments are applicable independently and by no means inevitably in the connection where they have been presented in the above.